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Energising Renewables

On-Site Renewable Generation - Key Electrical Issues

Robert Mitchell

On-Site Generation Manager

(Client and project management)

Econnect

- “Energising renewables”
- Responsive: Econnect Consulting Ltd, Econnect Construction Ltd and Econnect Ventures Ltd businesses
- Offices in UK, Ireland, Australia & New Zealand
- Projects in over 20 countries
- Single on-site generators up to 1000MW offshore wind farm
- Wind Direct partnership: facilitating on-site generation from wind

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Agenda

1. Background introduction to network and issues
2. Different types of generation
3. Key electrical issues
4. Example 1 – industrial site, no “spill”
5. Example 2 – rural site, mostly export
6. Practical issues
7. Summary of solutions
8. Conclusions & Questions

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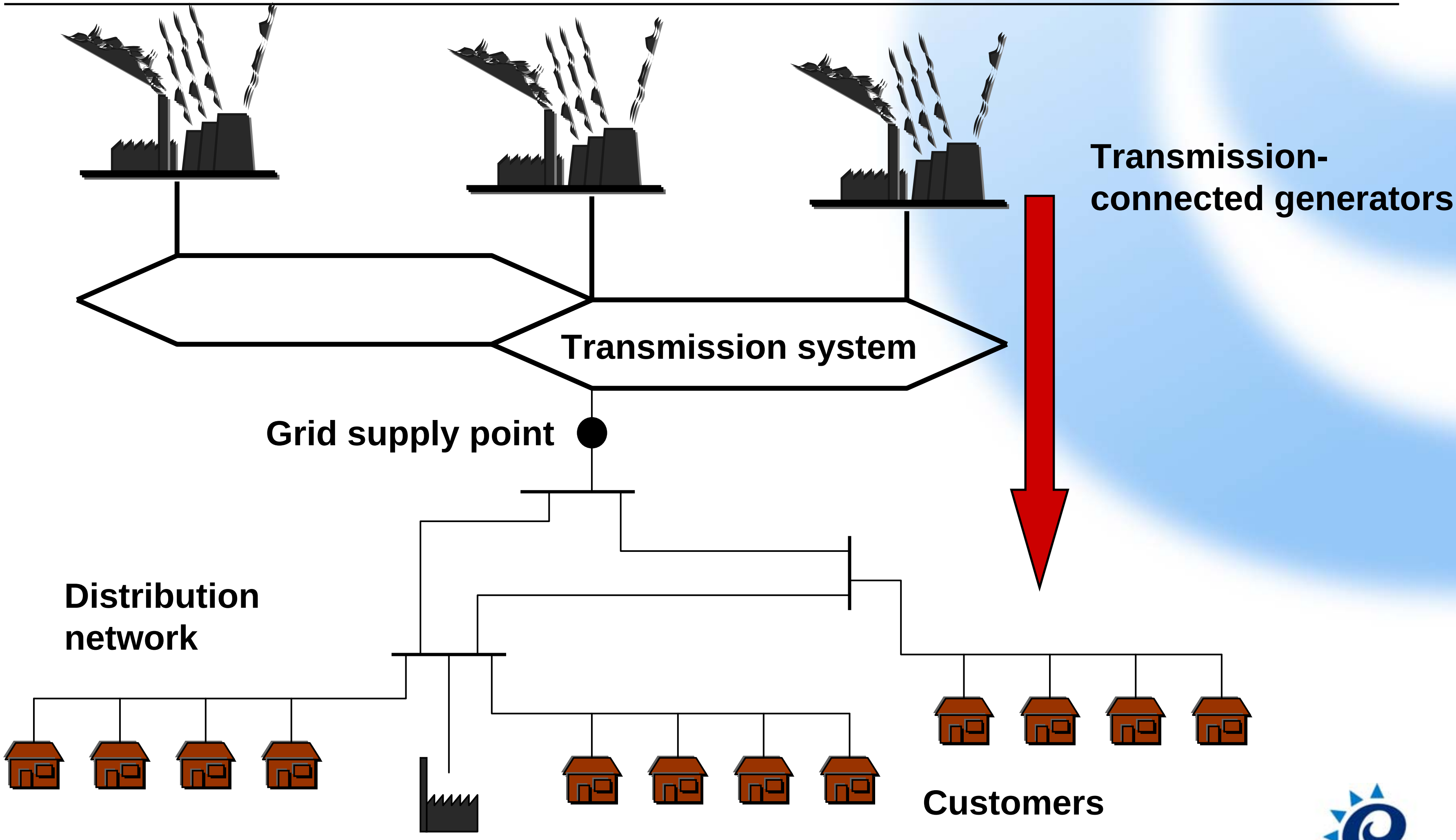
Power flows in a traditional network



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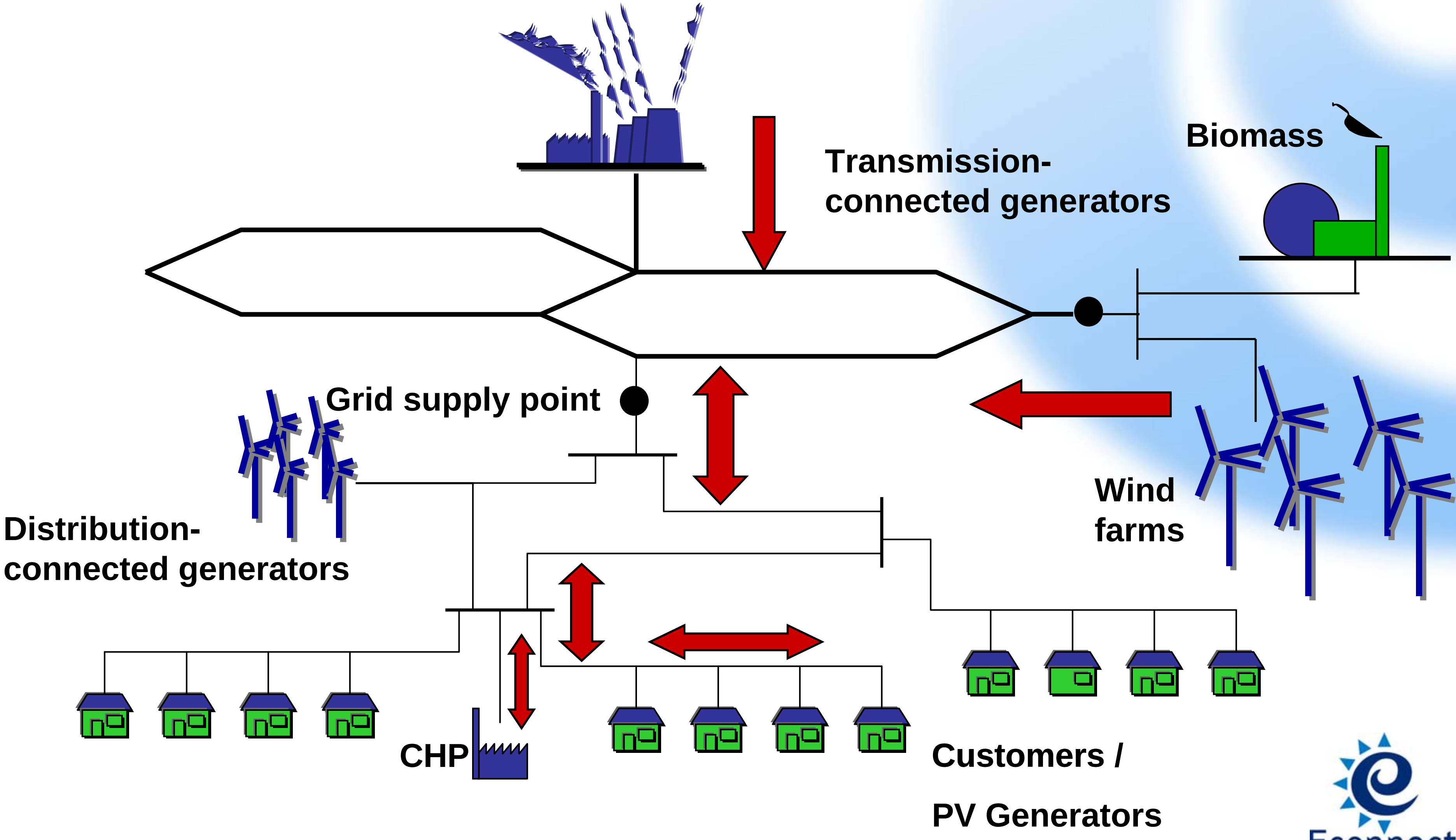
The changing network



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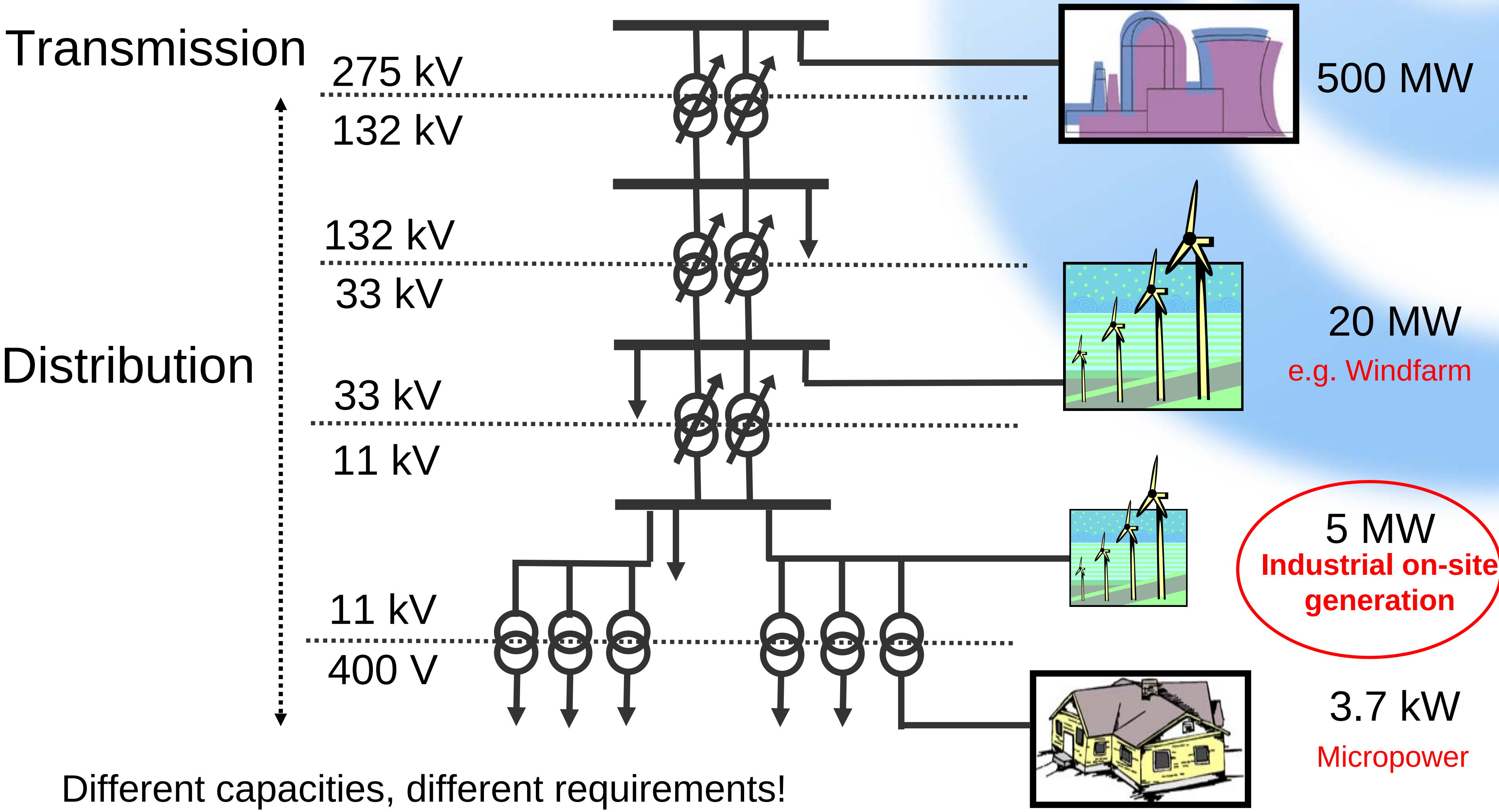
Renewable generation on the network



Different capacities, different requirements!

On-site generation technologies

Asynchronous (induction) rotating machines

•Induction motor type design

•Typically simpler, cheaper, more reliable

•Historically direct-coupled

•Modern hybrids include Doubly Fed Induction Generators

•Not widely used as generator outside wind and small scale hydropower machines

Synchronous rotating machines

•Generated voltage synchronous with rotational speed

•Modern wind turbine versions include variable speed, full-scale converter coupled types with reactive power control

•Also used in CHP plants

DC current sources

•Inverter-coupled to ac network

•E.g. solar PV, fuel cell

•Normally associated with micropower …

• … but efficiencies and scales improving?

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Key Electrical Issues

- Equipment issues:
    - Thermal limits
    - Reverse power flows
    - Fault level limits
- Voltage control issues:
    - Voltage rise issues
    - Voltage step issues
    - Voltage flicker issues
    - Harmonics

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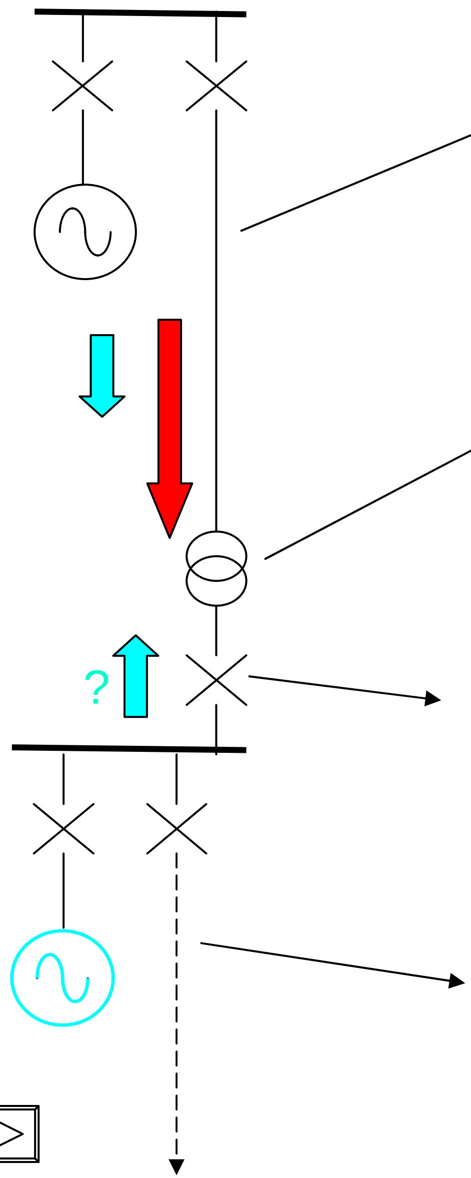
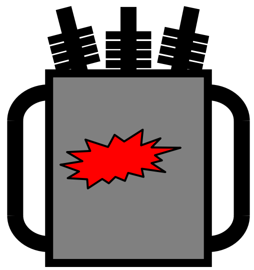
Thermal Limits



Overhead line

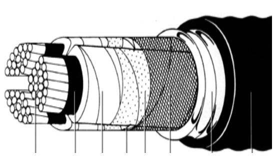


Transformers

- Overheating leads to insulation failure
- Reverse power flow capability?

Switchgear

- Overheating leads to insulation failure



Underground cables

- Overheating leads to insulation failure

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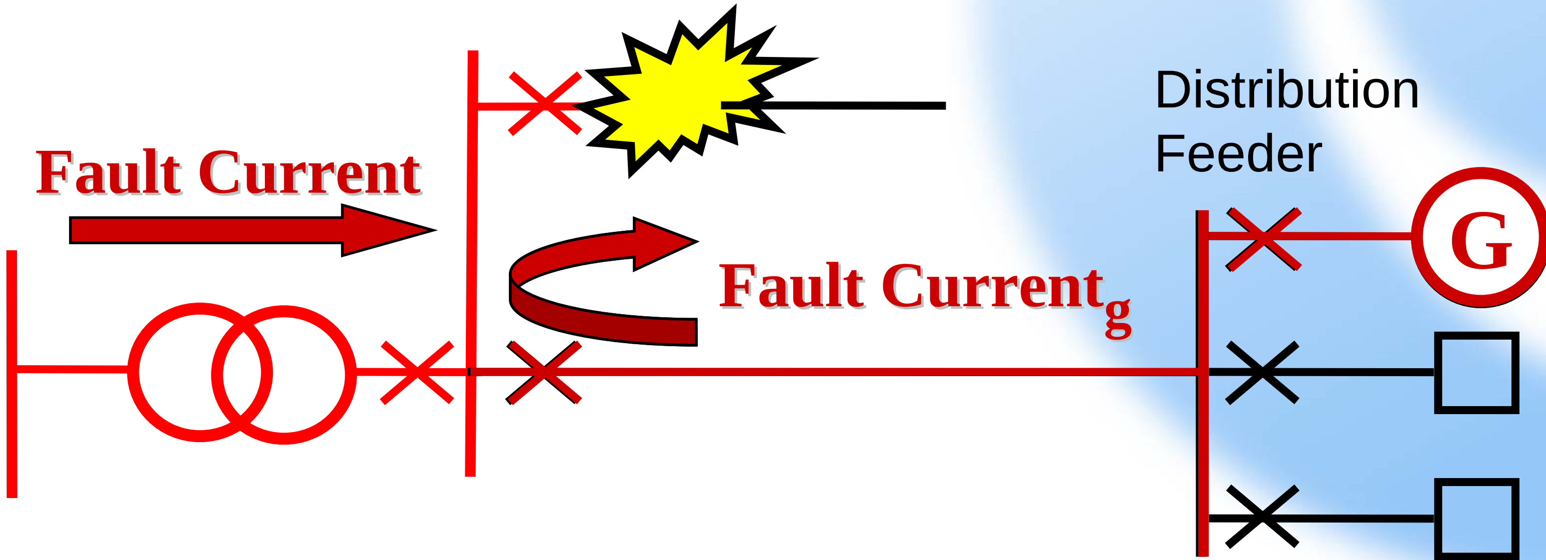
Fault Level Limits



Contribution of current to a fault on network can lead to an overstressing of existing switchgear and is a major limiting factor to the connection of embedded generation

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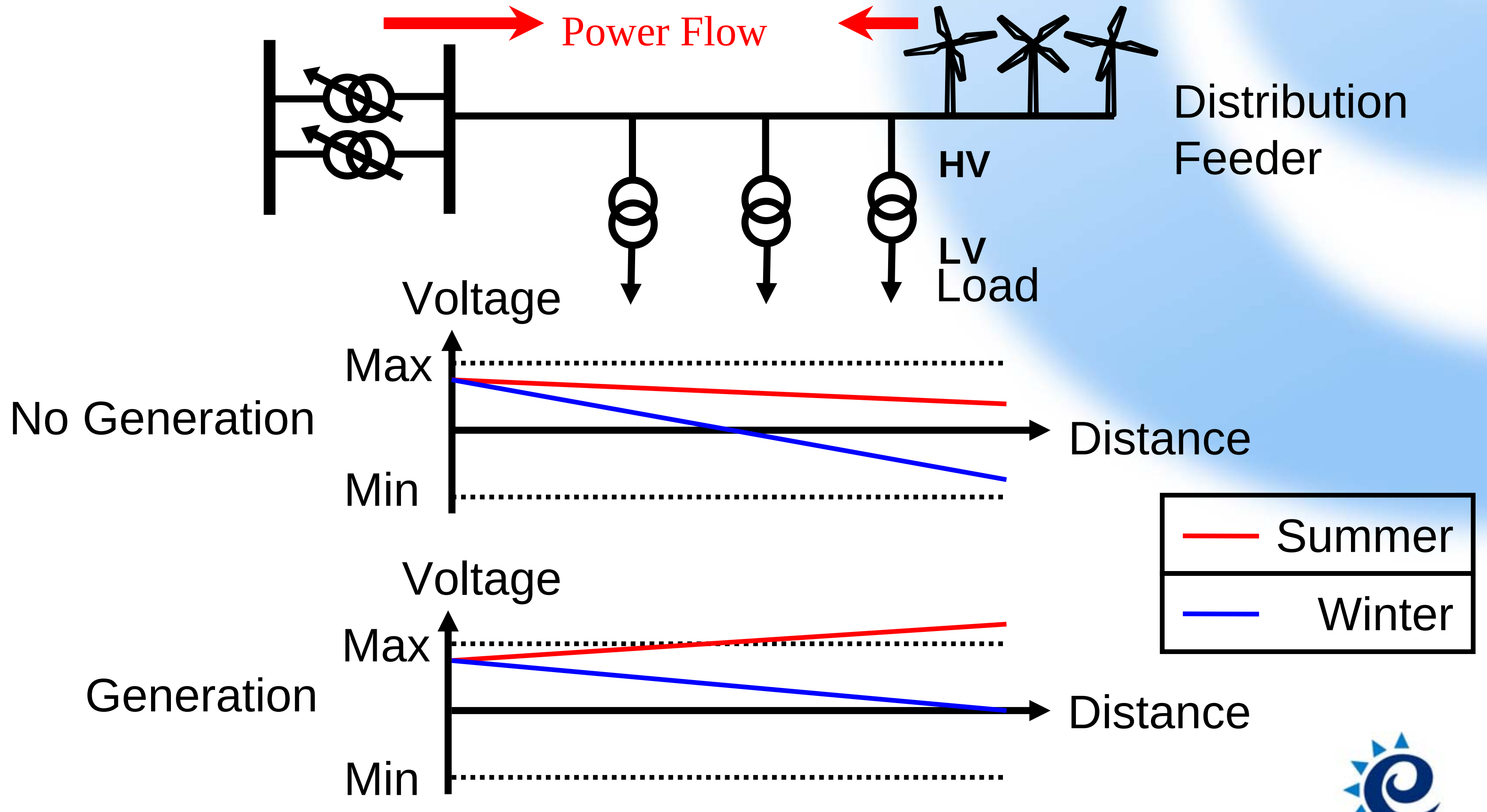
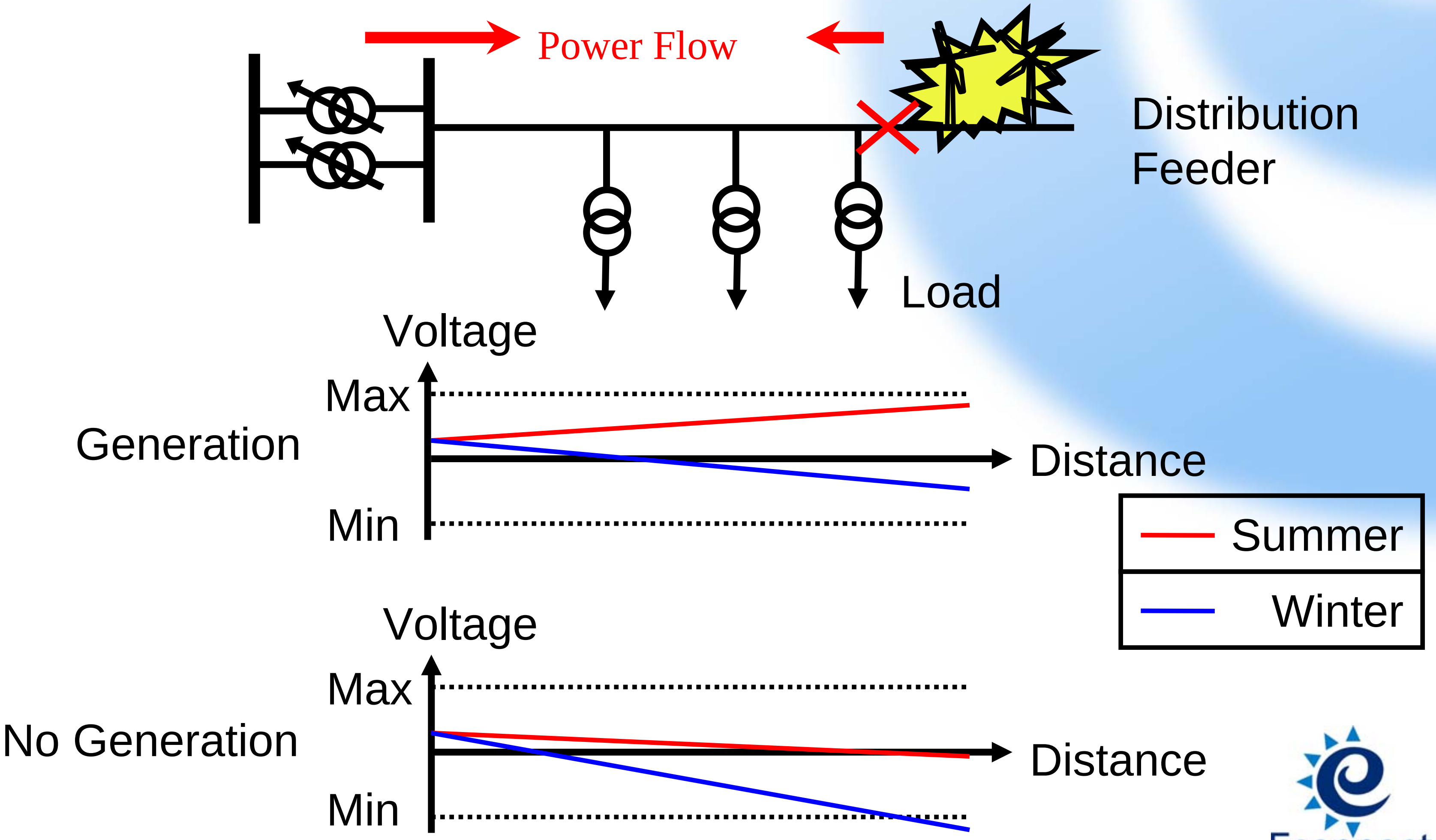
Voltage Rise (Steady State)



Worst case: high generation, low demand

Voltage Step



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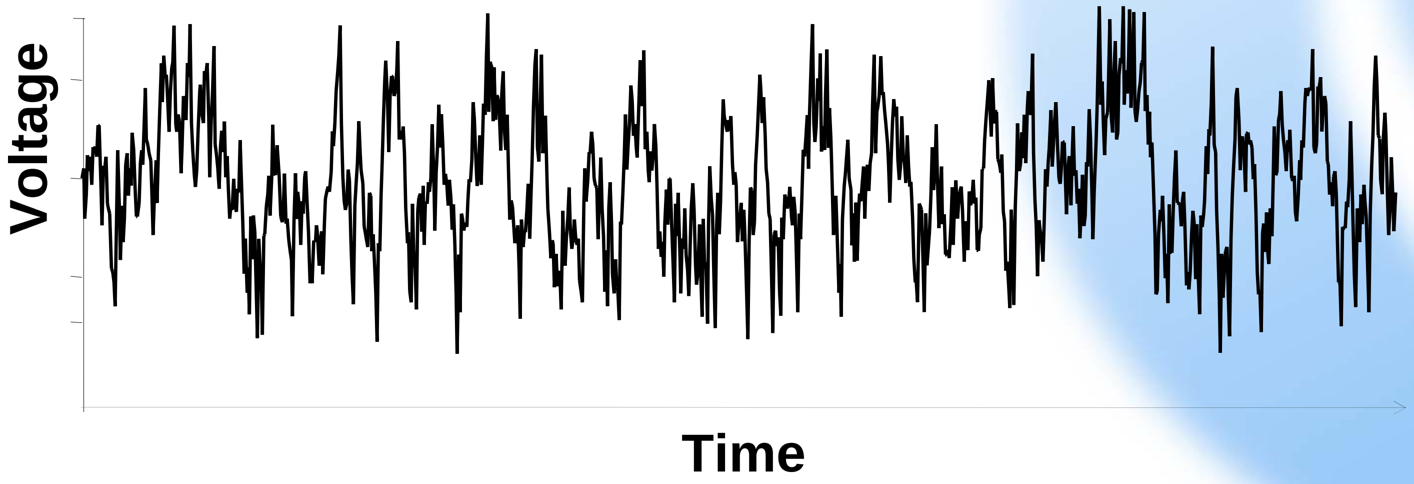
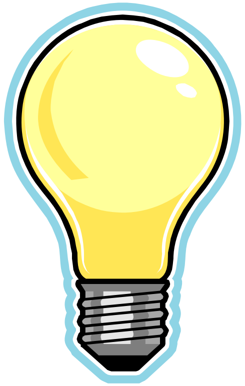
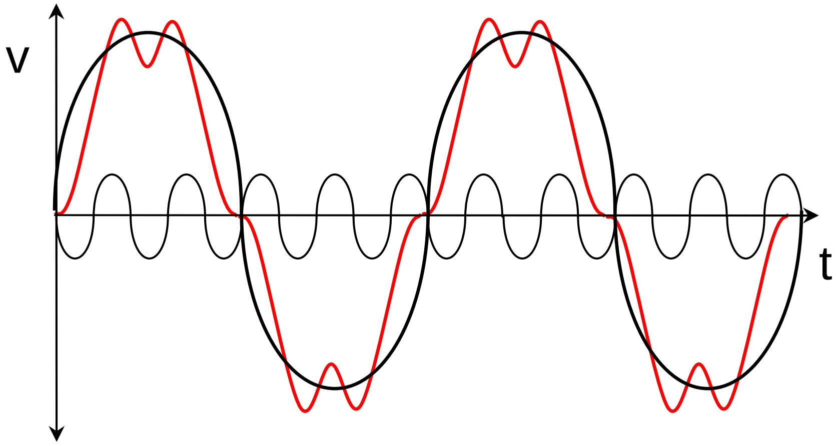
Voltage Flicker



Visually noticeable:



Harmonics



- Ideal: perfectly sinusoidal waveform at 50 Hz
- But: some forms of generator use non-linear power electronic components to convert output to grid voltage -
    - introduces (limited) harmonic components to waveform
    - cumulative effects of local generation can:
        - create hotspots in transformers
        - prevent electronic equipment operating properly

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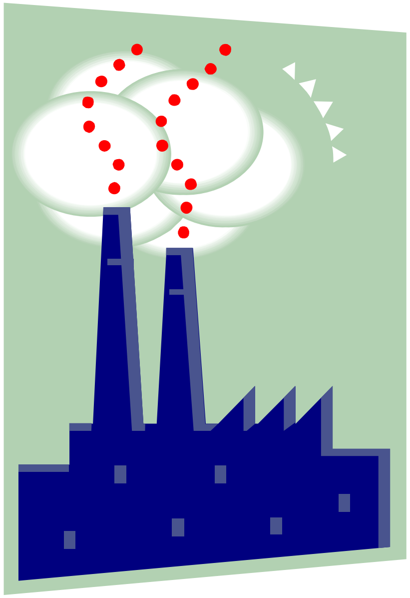
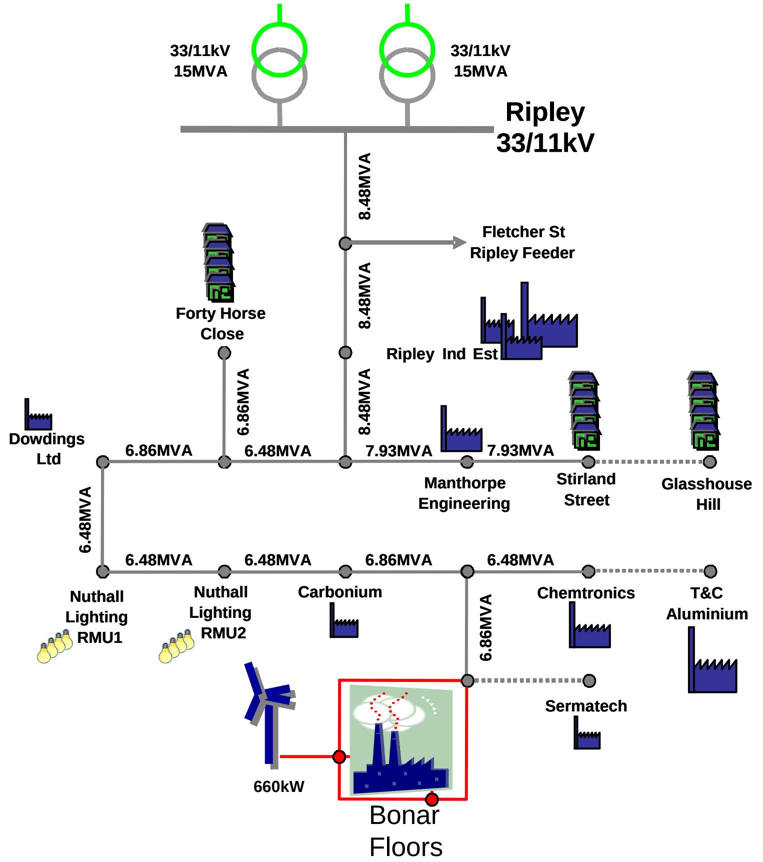
Example 1: Industrial site, no export



- Single 660kW synchronous turbine generator on industrial site
- Turbine connected to own on-site 11kV ring with 3 substations around site
- High on-site load – no “spill”
- On-site ring connected to local distribution ring via 11kV feeders

Example 1: Private 11kV network



Issues must be addressed to meet on-site power quality requirements

- Effects on private network primary concern
- Multiple connection options
- Generation small compared to existing on-site loads
- Issues may be acceptable on-site

- Effects on distribution network must still be considered e.g.
  - Voltage step at energising?
  - Fault contribution?

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Example 2: Rural network, full export

- 2 x 2MW on-site turbines
- Turbine connected directly to rural 11kV radial distribution network
- Low on-site local load, mostly export

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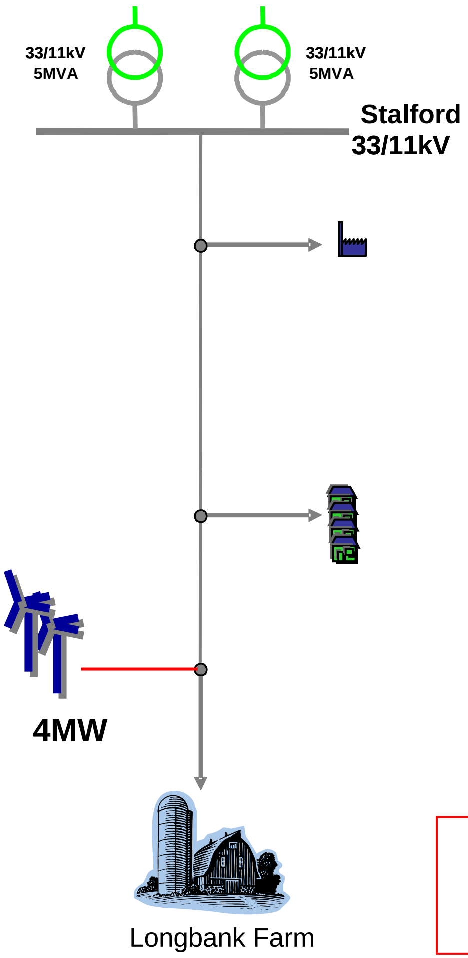
Example 2: DNO 11kV network Issues



- Limited connection options
- Generation large compared to local demand
- Network not designed with such power flows in mind

- Reinforcement likely

Issues must be addressed to meet DNO requirements for export

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Generally …

- Case-by-case integration assessment required
  - Different connection options should be considered
  - Consider both on-site networks and DNO networks
- Urban networks
  - Tend to be “stronger”
  - More complex integration assessment required
  - Local loads – less of network affected
- Rural networks
  - Likely to be “weaker”
  - Export to remote loads – long length of network affected
  - More likely to require reinforcement

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Practical Issues

- Connection options available?
- Step-up at turbine?
- Cable route – obstacles? – disruption?
- Type of connection? T-in, Loop-in, Busbar?
- Metering for ROCs?

DIFFERING CONNECTION OPTION COSTS?

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Summary of solutions

- Generation side:
  - Addition of mitigating technology
  - Conditional constraints on export
  - Constraints on total generation capacity

- Network side (by DNO) :
  - Reinforcement
  - Reconfiguring equipment or network

The future? Innovative solutions – for example …

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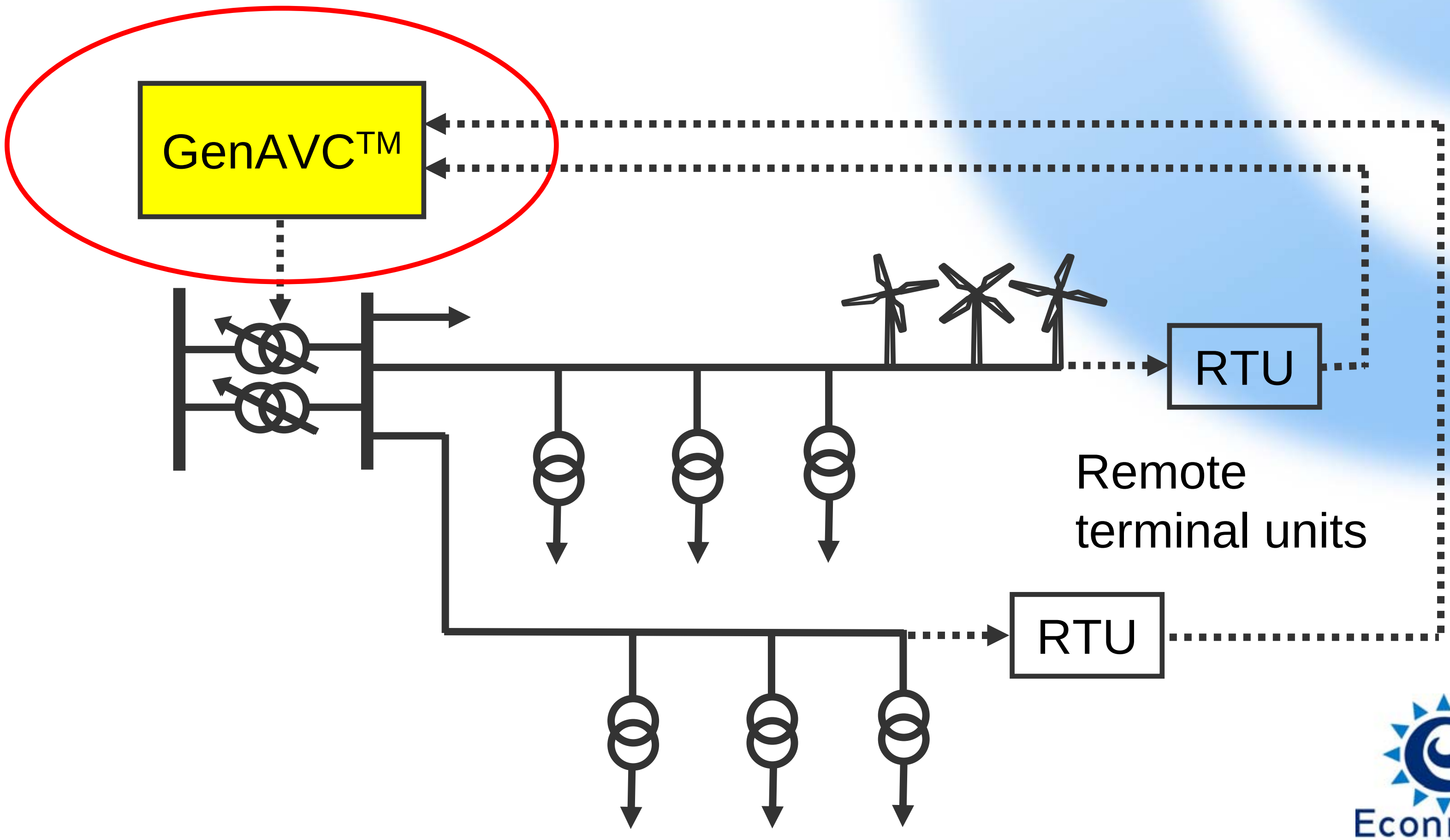
Network product solution to voltage rise issues (Econnect Ventures Ltd) – Gen AVC™



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Conclusions

- Electrical issues can arise, and will need assessed
- Generation must comply with strict standards for grid connection
- Solutions can be usually be found!!

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Thanks!

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